Invitation Email

- The topics covered include academic subjects which typically are addressed by faculty members of UCF or those of neighboring colleges and universities, issues of the day that are presented by prominent members of the Central Florida Community, or invited guests who are at UCF representing the Global Perspectives Program of the university.

- We would like very much to have you speak to our membership on the subject of Forensic Chemistry and its many practical applications. Our membership would be greatly interested in learning more about your profession and your interest in this subject. Each presentation normally is 45 minutes in length, with 15 minutes for Q&A following the presentation.
Real Shows!

- Forensic Files
- Unusual Suspects
- The First 48
- The New Detectives
What is Forensic Science?

The use of science and technology to enforce civil and criminal laws.
Types of Forensic Crime Laboratories

Federal

Military

State

County

Local
Crime Scene Investigation

- Blood Spatter
- Body Positioning
- Footprints
- Fingerprints
Examples of Trace Analyses

- Fire Debris
- Explosives
- Paint
- Gun Shot Residue
- Fibers
- Glass
- Physical Comparisons
- Hair
- Soil
- Miscellaneous
My Background
Who Am I?

- Trace Evidence Examiner
  - *Fire Debris*
  - *Explosives*
- Project Manager for Forensic Research
- Research/Internship Coordinator
- Human Research Protections Officer

- Conducted Research for the Crime Lab
  - *Case Specific*
  - *Operations Specific*
Research Overview

- Foundational Exploration in Forensics
  - *Explore the basics that forensics was developed upon*
  - *Following Research Areas*
    - Lubricant Analysis
    - Colorimetric Detection of GSR
    - Detection of Illicit Drug Suppression Agents

- Transition of technology into operational uses
FORENSIC CHEMISTRY APPLICATIONS
Forensic Chemistry Areas

- Drugs
- Toxicology
- Fire Debris
- Explosives
- Lubricants
- Ink Analysis
- Fibers
- Soil
- Glass
- Tape
- Gunshot Residue
Illicit Drug Analysis

- GC-MS
Fire Debris Analysis

- GC-MS

Gasoline
Classifications of Ignitable Liquids?

- Gasoline
- Petroleum Distillates
  - Light
  - Medium
  - Heavy
- Aromatic
- Isoparaffinic
- Napthenic-Paraffinic
- Normal Alkane
- Oxygenated
- Miscellaneous

ASTM E1618-14: ILR in Extracts from Fire Debris Samples by GC-MS
Explosive Analysis

- Low Explosives
  - Black Powder
  - Smokeless Powders
- High Explosives
  - TNT
  - RDX (C-4)
- Instrumentation
  - Microscopy
  - GC-MS
  - Flame Tests
  - Chemical Tests (nitrates)
Explosive Analysis

TNT

RDX

Trinitrotoluene MASS SPECTRUM

NIST Chemistry WebBook (http://webbook.nist.gov/chemistry)
Explosive Analysis

Pipe Bombs

Chemical Reaction Bomb
Other Areas

Nylon Fiber Cross-Section

Carpel Fibers

Nylon Fiber in Polarized Light

(a)  (b)  (c)  Figure 11

Physical Fit Between Known (Right) and Questioned (Left) Duct Tape Samples
Purpose of the Research Area

- Nearly 1 in 5 (18.3%) women and 1 in 71 (1.4%) men have reportedly experienced a sexual assault in their lifetime.\(^1\)
- Recently, there has been an increase in sexual assault cases involving condoms to mitigate the transfer of biological evidence.
- Increased emphasis has been placed on identifying novel techniques for the characterization of lubricant evidence.

Project Objective:

- Develop a classification scheme for the analysis of lubricants and establish a publically available lubricant database that will assist in forensic casework.

Why Look at Lubricants?

- Sexual Contacts i.e. Sexual Assaults/Contact
- Tampering Cases
  - Automobile tampering
  - Industrial tampering
- Fraud Cases
  - My car failed due to the brakes – Not True

- Relatively new field of analysis
Lubricant Definition

- **Definition of a lubricant:**
  - *substance introduced to reduce friction between surfaces in mutual contact* (Wikipedia)

- **Types of lubricants**
  - *Water based*
  - *Petroleum based*
  - *Synthetic Oil*
  - *Natural or Edible Oil based*

- **States of lubricants**
  - *Liquid: Oil, PDMS*
  - *Semi-Solid or Solid: Grease*
  - *Dry or Powdered: Starch, dry graphite*
Condoms

Personal Lubes

Oils

Mech. Lubes

Medic. Lubes

Lotions

My Research Focus
Lubricant Areas
Good Lubricants

- High Boiling Points & Low Freezing Points
- Very Thick (i.e. Viscous)
- Highly resistant to Oxidation
- High Lubricity (i.e. Slippery Factor)

- Depending on the usage, manufacturers can include additives
  - Sensations (warming, cooling, etc)
  - Sensitizers
  - Flavors and Aromas
Common Lubricants

- Tocopheryl Acetate
- Nonoxynol-9
- Polydimethylsiloxane (PDMS)
- Hydroxy-PDMS
- Cyclopentasiloxane
Current Lubricant Analysis

- Current Analytical Techniques
  - Polarized Light Microscopy – Starch, Particulates
  - Infrared Spectroscopy – Polydimethylsiloxane (PDMS)
  - GC-MS – Nonoxynol-9

[Graphs and images showing analytical data and results]
Lubricant GC Examples - Complex

Questioned

Known
Lubricant Analysis

- Needs a method to classify lubricants
  - Similar to Ignitable Liquids
- Create Classifications
  - Create investigative leads
- Could we identify manufacturers???
  - Hasn’t really been done before
Lubricant Research Plan

- We will use current procedures as a baseline
  - DART-MS Data
  - GC-MS Data
  - IR Data

- Deconstruct Lubricants

- While the premise is classification, might also learn about
  - Lubricant wear over time – Understand the wear pattern
  - Identify DNA friendly techniques
  - Develop statistical measure for comparison
  - Identify different additives
## Lubricants Classes

<table>
<thead>
<tr>
<th>Lubricant Group</th>
<th>Component/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Glycerol, PEG, Parabens, CMC, H₂O</td>
</tr>
<tr>
<td>Silicone</td>
<td>PDMS, Hydroxy-PDMS</td>
</tr>
<tr>
<td>Oil/Petroleum</td>
<td>Hydrocarbons</td>
</tr>
<tr>
<td>Organic/Edible</td>
<td>Glucose, Chlorhexidine, Butter, Oils</td>
</tr>
<tr>
<td>Condoms[^2]</td>
<td>Nonoxynol-9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sub-Category</th>
<th>Component/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthetics</td>
<td>Benzocaine, Lidocaine</td>
</tr>
<tr>
<td>Sensatory</td>
<td>Capsaicin, Peppermint, Cinnamon</td>
</tr>
<tr>
<td>Flavors</td>
<td>-</td>
</tr>
</tbody>
</table>

DART Source

Figure 1: Schematic diagram of the DART source.[3]

Mode of Ionization - Positive

The metastable He atoms generated by the DART source react with atmospheric water to produce protonated water clusters which can then ionize the analyte (M).

\[
\begin{align*}
(1) & \quad \text{He}(2^3S) + \text{H}_2\text{O} \rightarrow \text{H}_2\text{O}^+ + \text{He}(1^1S) + \text{e}^- \\
(2) & \quad \text{H}_2\text{O}^+ + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{OH}^- \\
(3) & \quad \text{H}_3\text{O}^+ + n\text{H}_2\text{O} \rightarrow [(\text{H}_2\text{O})_n\text{H}]^+ \\
(4) & \quad [(\text{H}_2\text{O})_n\text{H}]^+ + \text{M} \rightarrow [\text{M}+\text{H}]^+ + n\text{H}_2\text{O}
\end{align*}
\]
Mode of Ionization - Negative

Metastable He atoms can interact with a neutral (N) species to form electrons via Penning ionization. These electrons react with $O_2$ (g) to generate $O_2^-$ which can then in turn ionize the analyte/s (M).

\begin{align*}
(1) & \quad \text{He}(2^3\text{S}) + \text{N} \rightarrow \text{He}(1^1\text{S}) + \text{N} + \text{e}^- \\
2( ) & \quad \text{e}^- + \text{G} \rightarrow \text{G}^* + \text{e}^- \\
(3) & \quad \text{e}^- + \text{O}_2 \rightarrow \text{O}_2^- \\
(4) & \quad \text{O}_2^- + \text{M} \rightarrow [\text{M-H}]^- + \text{OOH}^+ \\
(5) & \quad \text{O}_2^- + \text{M} \rightarrow \text{M}^- + \text{O}_2 \\
(6) & \quad \text{O}_2^- + \text{M} \rightarrow [\text{M}+\text{O}_2]^-$
\end{align*}
Experimental

JEOL AccuTOF™ DART 4G

*Dart Source*
He gas
DART Gas Temperature: 350 °C
Needle Voltage [V]: 2000 V
Exit Grid Voltage [V]: 250 V

*AccuTOF*
Orifice 1 [V]: 20 V
Ring Lens [V]: 5 V
Orifice 2 [V]: 5V
Ion Guide Rf [V]: 600 V
Detector [V] = 2100 V
Reproducibility
Positive-Ion Mode

**Ingredients**
- Propylene Glycol
- Glycerol
- Methylparaben
- Propylparaben
- Polyquaternium 15

Astroglide
Mode of Ionization

Nuru Positive Mode

Nuru Negative Mode
Anesthetics

Passion

Anal Eze
Sensations

Jo \( \text{H}_2\text{O} \)

Jo \( \text{H}_2\text{O} \) Warming
Flavors

Wet Flavored Raspberry-Pomegranate

Wet Flavored Blueberry
Silicone Lubricants

Astroglide Silicone

Pink

Pjur Backdoor

Pjur Original

Swiss Navy Silicone

m/z
Cluster Analysis of Silicone Lubricants
Project Conclusions

- It has been demonstrated that DART-TOFMS is capable of rapidly characterizing water-based personal lubricants with minimal sample preparation.

- DART-TOFMS is not only capable of discriminating between water-based personal lubricants, but can also identify the sub-category of lubricants based on the presence of anesthetics, sensations and/or flavors.
INTERESTED IN FORENSIC SCIENCE
General Forensic Programs

Laboratory Examiner
- Science Basis
  - Chemistry
  - Biology
  - Physics
  - Instrumental Analysis
- Can move to crime scene
  - We have to learn how to collect the BEST evidence
- Rarely go to crime scenes
- INTERNSHIPS!!

Crime Scene Technician
- Criminal Justice
  - Criminal Law
  - Evidence
  - Criminalistics
  - Medicolegal Death Inv.
- Collection of evidence from the crime scene
- Can not move to examiner
  - Unless you have a the science
- INTERNSHIPS!!
UCF Forensic Science Program

Undergraduate (B.S.)

- **Tracks**
  - Forensic Analysis
  - Biochemistry (DNA)
  - Behavioral Forensic (Cert)
  - Crime Scene Inv. (Cert)

- **Requirements**
  - 2.5 min GPA in major

Graduate (M.S.)

- **Tracks**
  - Forensic Analysis
  - Biochemistry (DNA)
  - Forensic Professional
  - Digital (Certificate)

- **Program**
  - Completely Online
  - Thesis Option - Research
  - Non-Thesis Option
Gunshot Residue Colorimetric Tape

- Types of Gunshot Residues (GSR)
  - Inorganic Residues
    - Barium
    - Antimony
    - Lead
  - Organic Residues
    - Nitrates
    - Pthalates

- Current State of GSR Collection and Processing
  - Not great
  - ~ 4 hour timeline for inorganics and organics
Current GSR Collection

Inorganic Tests
- SEM Stubs

Organic Tests
- Field detection
- Colorimetric tests
  - Nitrates
  - Lead

Sandia.gov
Agarscientific.com
GSR Tape Research Goal

- Develop a GSR Colorimetric Tape
  - Organic – Immediate Colorimetric Response
  - Inorganic – Collection for SEM

- Simultaneous collection for dual tests
GSR Tape Research Plan

■ Understand the complex problem – ID residues
  - Organic – smokeless powders
  - Inorganic – Primers, event metals (weapon action)
  - Lead-Free - DDNP

■ Identify current colorimetric processes
  - 1 step process - Can be done in a dry environment
  - 2 step process – Add a catalyst
  - Can easily be incorporated into a sticky polymer

■ Test the final composite
  - Does it hold particles?
  - Are adverse peaks observed in SEM analysis?
  - Accurately IDs GSR residues?